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Editorial

THE PROFESSION AND THE WAR

THERE are few who in the year 1918 would have ventured to prophesy that the world would be engulfed again in the holocaust of war in a period of twenty years. The causes of the present conflict are so manifest that it behoves all of us to bend our wills to the task before us in the fight of might *v.* right. It has been said that science knows no boundaries, and that all scientists are, in reality, members of one big family . . . if this is so, how is it that the world is again in turmoil, for in a modern war cold-blooded science is supreme and friendship and humanity are at a discount?

It may be that the veterinary profession will be called upon to render service with the armed forces, as it did so nobly in the last great war. We have no hesitation in saying that if such a call comes the response will be one hundred per cent. Wars are not won by force of arms alone, economic and productive factors play their part. Nations which are economically strong and whose industries are able to stand up to the wear and tear of war wastage will ultimately prove to be the victors.

It is in this class of service that the veterinary profession may perhaps pull its greatest weight. It is our duty to do all we can to conserve the animal population, to increase their productiveness, to combat disease and to so arrange that the fullest use may be made of all animal products and by-products. It is fortunate that the State Veterinary Service has had time

to become established on a sound footing, for in it we have an organisation which is capable of providing for all military and civil needs, and is also capable of immediate expansion if such should be necessary. This Journal was prepared for the press before the outbreak of war, but it is a fortunate chance that it should be replete with authoritative articles dealing in various ways with sheep husbandry. At such a time as this these articles will, we trust, be of greatest service, and it will be our endeavour to see that future numbers may contain material of equal economic importance.

It is inevitable that all printing activities will suffer disabilities and restrictions as a result of war, but in the years 1914 to 1918 this Journal was able to carry on, and it is certainly our intention to continue publication during the coming years. We hope that the duration of the war will not be long, but who knows? Long or short, there will be a continuing need for veterinary literature and it will be our duty to continue with all our power to provide for that need.

By making full use of the loyal services of the Veterinary Profession, the Empire will be able to strike a blow for liberty and freedom such as will astound the world.

General Articles

THE ECONOMIC IMPORTANCE OF IXODES RICINUS

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General

ATTENTION has recently been focused on the formidable nature of the British sheep tick, Ixodes ricinus L., which, in addition to being a blood-sucking parasite of mammals and birds, transmits several widely spread and fatal diseases to sheep, and also to cattle. Few figures are available to enable the veterinarian to assess the economic losses from these tick-borne diseases, namely, louping-ill, tick-borne fever, tick pyæmia and redwater, but it is now certain that they are responsible for enormous wastage throughout the geographical range of tick distribution. This includes large areas of rough grazings in Scotland, the North of England, Wales and South-West England. Much of the hill land in Britain is farmed or ranched at a low level of productivity, and although many factors, mostly economic, undoubtedly contribute to this, those aware of the facts must be impressed by the higher mortality rate and poorer returns from farms severely infested with ticks. The opinion may be hazarded that the productiveness of hill farming over large areas is consistently reduced by at least 10 or 15 per cent., principally through the depredations of ticks.

Losses from Tick-borne Diseases

Home-bred adult sheep—and lambs which survive one year on tick-infested grazings—possess considerable immunity to the tick-borne diseases. This is clearly shown by the low mortality rates amongst the adult stock of many farms known to be severely infested with ticks. It is further strikingly illustrated when non-native sheep (unacclimatised) are transferred to tick-infested pastures during the active tick season. Whenever this type of movement takes place the losses are always high, while the adult native stock, grazing over the same pastures, remain in apparently perfect health. The following flock histories illustrate this.

Farm A.—One hundred and forty-three ewes and 140 lambs, all from healthy pastures, were moved to ticky land in May, 1935. Deaths from louping-ill commenced two weeks later and continued until the autumn. By

November, 230 animals (81 per cent.) had died. During this period the mortality amongst the native sheep was very slight.

Farm B.—Two hundred ewes and their lambs, all unacclimatised, were moved to tick-infested pastures in May, 1934. The death-rate from louping-ill during the following three months amounted to approximately 50 per cent.

Farm C.—One hundred and twenty tegs were placed on enclosed pastures in March, 1935. Ten days later all were suffering from an unknown malady later diagnosed as tick-borne fever. Thirty tegs died. Inquiry showed that the fields had become contaminated with ticks which had dropped off the previous occupier's sheep. These sheep were known to have been moved during the tick season from tick-infested grazings.

Farm D.—Fifty pregnant, unacclimatised ewes were moved to tick-infested land in March, 1928. Twenty-six ewes lambed prematurely. In all probability these ewes were affected with tick-borne fever. Amongst native stocks in this area the abortion rate is never high.

Unfortunately the immunity built up in native sheep is apparently not transmitted in appreciable degree to the lambs, and in consequence it is amongst the lamb crop that the biggest losses from tick-borne diseases are met with. Louping-ill is sometimes seen in young lambs, and while this disease can be effectively controlled by vaccination in the case of adult sheep, as yet no specific means of preventing it in young lambs has been devised. In the North of England, however, experience shows that by far the commonest tick-associated disease of lambs is pyæmia.

Farm E.—Heavy losses amongst lambs were reported from sheep farms in a tick-infested valley in Northumberland, and in May, 1937, it was decided to establish a field laboratory to investigate the cause of these deaths. This inquiry was made possible by a special grant from the Agricultural Research Council.

Arrangements were made to collect, as far as possible, all dead lambs from these farms and convey them daily by car to the field laboratory, where they were submitted to a detailed post-mortem examination. In fifteen days during May, 1937, 110 lambs were received and examined, and the following causes of death noted. It was impossible to examine all lambs which died, and 110 represents only a proportion of the total losses during this period.

	No. of cases
Pyæmic infections alone	30
Cl. welchii Type D infection alone	18
Pyæmic infections plus Cl. welchii Type D infection ...	20
Lamb dysentery	5
Incidental deaths (known causes)	9
Suspected tick-borne fever	5
Indefinite	23
Total	110

It will therefore be seen that pyæmic infections of varying severity were encountered in 50 lambs, and were believed to have been responsible for death in 30 cases. Biological tests for the detection of the louping-ill virus were not carried out, so that some of the undetermined deaths may have been due wholly or in part to this virus. The possibility of the existence of occult pyæmic lesions in this group cannot, however, be overlooked.

Tick Pyæmia in Lambs

This information clearly illustrates, *inter alia*, the great importance of properly organised field studies, for in no other way could the above information have been obtained. It proved that on these tick-infested farms by far the biggest individual cause of death was not louping-ill or even tick-borne fever, but a distinct infection which the writer termed tick pyæmia. Pyæmia, as the name implies, evinces itself as a generalised septic condition, characterised by multiple abscess formation on the skin and throughout the internal organs and joints. The causal micro-organism is a staphylococcus which invades the blood and lymph streams, in all probability via wounds produced by tick bites, whence it is conveyed throughout the body. Bone tissue, particularly the bodies of the dorsal and lumbar vertebræ, is frequently attacked, with resultant spinal meningitis and posterior paralysis, but the site of fatal lesions is probably fortuitous. In addition to the meninges death may occur from pyelo-nephritis, adhesions of the heart, lungs and liver to the diaphragm, peritonitis, pleurisy and verrucose endocarditis. Lambs are infected shortly after birth, but the onset of the disease is insidious; it runs a chronic course and produces death only when the functions of a vital organ are seriously impaired. This may occur when lambs are two to six or eight weeks old. The symptoms shown by affected lambs resemble those of "joint ill" or "navel ill," but these diseases are manifestly distinct. True streptococcal joint ill is seldom met with amongst hill flocks, and pyæmia of the above type has not been observed on tick-free farms.

It is of interest to note that few lambs were found to have died from the better-known tick-borne diseases, viz., louping-ill and tick-borne fever. Field studies have shown, however, that flockmasters are unable to distinguish between the tick-associated diseases. It is still true, as observed by Sir John M'Fadyean in 1894, that the general term "louping-ill" covers at least three ætiologically distinct diseases. In considering how these losses can best be prevented it will be appreciated correct diagnosis is of primary importance.

The disease known as redwater fever occurs in cattle throughout Britain. It is caused by an intracellular parasite of the red corpuscles (Babesia bovis), and in Britain the disease is spread by larval, nymphal and adult forms of Ixodes ricinus. Part of the developmental changes of B. bovis are undergone within the body of the tick, and it is known that the sporozoites are transmitted from the female tick to the eggs. In the North of England redwater fever occurs fairly commonly, but is not believed to produce heavy losses.

The Spread of Ticks

There is a fairly widespread belief amongst those farming in established tick areas that ticks have recently increased not only in numbers but have spread to farms hitherto considered tick-free. A closer acquaintance with the problem, however, shows that it is difficult to refute or confirm this view. Of themselves ticks are capable of very little movement on the ground. They are entirely dependent on their hosts for spread. This fact at once does away with the idea of an advancing army of ticks yearly colonising fresh territory. The known and old-established tick areas are still the main centres of tick activity, and land in the adjacent valleys may still be astonishingly free from ticks. That a whole valley to all intents and purposes should still be tick-free, despite occasional infestations caused by moving sheep from neighbouring infested valleys, is a matter for surprise, and indicates that Ixodes ricinus requires fairly precise environmental conditions for its permanent survival. In other words, one limiting factor in tick spread is the amount of suitable land available.

It seems moderately certain, however, that ticks have recently increased in numbers in some areas at least, and where this has occurred it is clear that adjacent farms must also carry higher infestations. The reason for this is to be found in the fact that in nature tick spread is continually occurring through the unrestricted movement of game, vermin and straying sheep. There can be no absolute line between tick-infested and tick-free land. This fact may remain entirely unsuspected for years, because in the absence of new or obscure diseases there may be no occasion to examine sheep minutely during the active tick season. Where tick-borne diseases suddenly make their appearance, however, a recent tick invasion is immediately suspected, but this is more likely to be accounted for by the introduction of disease into an established tick population of low density.

It is, moreover, only within the last ten years that farmers have come to recognise the true culpability of ticks in causing disease and wastage amongst sheep and lambs. This to some extent at least explains the present interest in the sheep tick. Outbreaks of disease which had proved exceedingly puzzling in the past can now be explained as due to tick-borne diseases, and much publicity has been given to accounts of losses among unacclimatised flocks which had been transferred to ticky pastures. Prevailing economic conditions in sheep farming have further stressed the importance of ticks, since what may still be a profit, despite losses, in good times, is converted into a heavy loss when times are less prosperous.

The chief agency in spreading ticks is indiscriminate movement of infested sheep during the active tick season. This may lead to permanent colonisation. For this reason it is risky to move sheep from infested pastures unless they are thoroughly dipped with an anti-tick dip just prior to movement.

In view of the fact that ticks act as vectors of the aforementioned diseases of sheep and cattle, it will be seen that the tick problem has an important veterinary bearing, and it is necessary to investigate how best the losses can be overcome. The veterinarian is no longer merely the farm physician. Viewed correctly, he is a guardian of the nation's food supply, and his work in conserving health in our flocks and herds is an indispensable contribution to national strength and security.

Northumberland Experiments

The elimination of sheep ticks from infested grazings is clearly the ideal line of defence against all tick-borne diseases, but at present this is quite impossible except perhaps occasionally in enclosed fields or parklands. Measures have, therefore, in general to be directed towards keeping the ewes and lambs as free as possible from ticks during the active tick season, and at the same time employing any other practical method for reducing the tick population. Of the many measures which theoretically it is possible to employ for tick destruction only two, viz., moor burning and sheep dipping, are considered to possess much value under practical sheep-farming conditions. Moor burning is of limited value since moors in Britain are seldom dry enough to allow the process to be really effective. Many of the standard commercial dips are effective tick-killers, and it has already been shown that pregnant ewes can be dipped six times, at five-day intervals, right to lambing time, using an arsenical preparation, without causing any appreciable injury to either the sheep or the wool. Dipping at such close intervals is unpopular, and is, of course, no solution to the problem because it is obviously ruled out as soon as lambing commences. This, unfortunately, is the time when dipping or alternative methods of control are most needed, since young lambs are more susceptible to tick-borne diseases than older sheep. In 1934, MacLeod discovered that dips compounded with certain natural greases were capable of preventing the reinfestation of dipped sheep for approximately ten to fourteen days, and this introduced an important advance in the technology of dips and dipping. Since 1935, field trials in Northumberland and elsewhere have confirmed that dips made as above and containing arsenic, phenols and wool grease slow down the rate of infestation, and have made it possible to lengthen the intervals between successive dippings.

Ewes and lambs have been systematically dipped at three-weekly intervals during the spring tick season. A deterrent effect has been noted for two weeks, whilst adult ticks which attach themselves to sheep during the third week have not completed their blood meal by the next dipping and are consequently destroyed. Despite the fact that this method of control is far from perfect, its adoption on certain farms since 1935 has been followed by a reduction in the tick population and a fall in lamb mortality. A full account

of these experiments appeared in the *Journal of the Royal Agricultural Society of England* (1936).

Protection of Ewes

Later work on tick control has been directed to lengthening the period of immunity from ticks. This is to avoid repeated dipping at close intervals. It is believed that if dipping could be made effective for three weeks, thus necessitating dipping every four weeks instead of every three weeks as formerly, the procedure would have practical possibilities for controlling ticks on British hill farms.

A sheep dip containing derris root was shown by MacLeod in 1932 to be an efficient tick-killer, but it was not known whether this substance also possessed repellent properties. Derris root is non-poisonous to stock, yet acts as a contact poison to ticks, keds, etc., and in view of these obvious advantages over arsenic (which is a stomach poison, and implies that the tick must first bite the sheep before it absorbs the arsenic which kills it), it was decided to run comparative field tests. The dips chosen contained either carbolic acid, derris or arsenic alone or in combination. The technical considerations involved in the making of these dips were covered by the Cooper Technical Bureau, and Dr. MacLeod of the Bureau staff assisted in the conduct of the experiments.

The following dips were used:

A.—A plain derris dip.

B.—Derris-carbolic dip.

C.—Derris-carbolic-woolfat dip.

D.—Arsenic-carbolic dip.

E.—Arsenic-derris dip.

Ewes in all five groups were dipped with the above dips a day or two before lambing, and thereafter at three-weekly intervals throughout the tick season. Twenty sheep were retained in each group as undipped controls, and comparative tick counts were conducted each week as required.

Results

TABLE I.—EFFECT OF FIRST DIPPING

Average Tick Counts (adult females)

(10 *dipped and* 10 *undipped sheep*)

Dips used April 14	Counts April 21		Counts April 28		Counts May 5	
	Dipped Sheep	Undipped Controls	Dipped Sheep	Undipped Controls	Dipped Sheep	Undipped Controls
A	21	35	50	54	17	8
B	39	52	75	73	—	—
C	23	26	65	40	—	—
D	5	29	31	39	15	16
E	4	30	23	50	18	14

These figures show that those derris dips which did not contain arsenic

possessed negligible tick-deterrent properties. It was found that such dips are efficient tick-killing agents but, under the conditions of the above test, they showed little value as repellents. This finding is not in agreement with the results of critical small-scale tests, and MacLeod suggests (private communication) that the discrepancy lies in the difference in immersion-time; the average hill shepherd immerses his sheep for something less than fifteen seconds. The duration of the actual period of immersions appears to be more important with derris than with other dips.

As a result, however, of the failure of the derris dips to protect sheep under field conditions, dips B and C were discarded at the second dipping on May 5 and dips A and E substituted. Dip D showed only moderate protection. The most satisfactory dip proved to be dip E, which showed a marked deterrent effect two weeks after use.

Protection of Lambs

The protection of young lambs from ticks presents the biggest problem. Lambs become infested soon after birth, but it is impracticable to dip them until they are about three weeks old. This is not primarily on account of the risk of injuring them, but chiefly because earlier dipping seriously interferes with the shepherd's other duties at a time when he is busiest. Yet if nothing is done in the interval lambs become severely bitten, and many are infected with tick pyæmia. For this reason the following experiments were undertaken:

(1) In a group of sheep with an anticipated lamb crop of about 100, the fleeces of half the lambs were dressed, as soon after birth as possible, by dusting with a powdered preparation of ground derris root, supplied by the Cooper Technical Bureau. Each alternate lamb born remained untreated to serve as a control.

A comparative tick count was made on May 6, when ten lambs from each group were examined. Counts were made on only the oldest lambs, those whose ages were estimated at between twelve and seventeen days.

Dusted lambs.—0, 0, 0, 3, 3, 6, 0, 0, 3, 0. Av. 1.5.

Untreated lambs.—12, 14, 13, 14, 6, 10, 15, 8, 14, 22. Av. 12.8.

The dusted lambs looked healthier, and the derris root had produced no harmful effect on the skin or fleece. In the dusted group the skin was smooth and healthy, but in the control lambs the skin was rough with numerous papillæ marking sites where engorged ticks had already fallen off.

All except six of the control lambs were dusted on May 6, and a comparative count was made on May 20.

Dusted lambs.—2, 7, 7, 6, 4, 0, 1, 4, 5, 3. Av. 4.0.

Untreated lambs.—23, 6, 10, 24, 16, 12. Av. 15.0.

A similar result was obtained in another group of lambs which were dusted on May 5. A comparative count was made on May 22.

Dusted lambs.—0, 4, 3, 3, 8, 13, 5, 4, 6, 8, 3. Av. 5.0.
Untreated lambs.—13, 21, 17, 13, 17, 17, 18, 23, 8, 10, 8. Av. 15.0.

(2) In another group of lambs it was decided to test the tick-deterrent value of an oily smear containing derris root when applied to young lambs soon after birth. Ten control lambs remained untreated. A comparative count was made on June 8. The technical considerations involved in the preparation of the salve were dealt with by Messrs. Robt. Young & Co., Glasgow.

Result

Smeared lambs.—Average 2.0.
Untreated lambs.—Average 6.8.

On July 11 all the lambs in this group were inspected and weighed, with the following result:

Smeared	*Untreated*
lb.	*lb.*
33	21
38	25
39	16
26	21
29	24
29	23
35	28
41	31
29	
29	
30	
40	
31	
42	
471	189
Av. 33.6 lb.	Av. 23.5 lb.

The average live-weights thus show a difference of 10 lb. in favour of the smeared lambs. Two control lambs had died from pyæmic infections and two were lame. In general, the smeared lambs looked much healthier and none was lame.

Conclusions

Of the many methods which may in theory at least be utilised to control sheep ticks, only one method—namely, protective sheep dipping—has as yet received much attention. Experience has shown that where the policy of protective dipping has been carefully carried out, and especially where lambs

have also been dipped, great benefit to the stock has resulted. Lambs rendered tick-free by dipping have been observed to rest and feed better, and therefore thrive better.

Protective dipping as above described, while undoubtedly useful, is merely a palliative measure and is unlikely to effect any quick reduction in the density of tick populations. More knowledge is required on the ecological relationships of Ixodes ricinus, because it is felt that a limiting factor to tick spread may be found in the physico-chemical nature of the soil and vegetation. Meanwhile research is continuing in an endeavour to discover the most useful anti-tick dips.

Two methods of rendering lambs tick-free have been tried, and the method of choice appeared to be the use of a powdered preparation of derris root. The dusting is quickly and easily carried out, produces no ill-effects, and dusted lambs remained remarkably tick-free for more than two weeks. An oily smear also proved useful. This smear checked tick-infestation, and smeared lambs were more thrifty and on the average 10 lb. heavier than the corresponding unsmeared lambs.

It will be appreciated that much more work along these lines remains to be done. Also the protection of sheep and lambs represents only one method of approach to the tick problem. More information is needed on tick ecology, and the specific immunisation of sheep and cattle against the tick-borne diseases is another possibility. These experiments are therefore being continued and considerably extended.

THE INCIDENCE OF COCCIDIOSIS OF SHEEP IN SCOTLAND

By U. F. RICHARDSON, B.Sc., M.R.C.V.S.
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In order to obtain specimens for teaching purposes an examination was made of the fæces of six sheep from the Edinburgh slaughterhouse for coccidial oocysts. The animals were selected at random, and the fæcal specimens were collected on three different days. All but one specimen contained oocysts. Examination was later made of sheep droppings from four farms, two near Edinburgh, one at Kelso, and one at Locherbie, and also from the intestinal contents of a lamb sent in for post-mortem examination from Fifeshire. In all cases coccidial oocysts were readily detectable by the sugar flotation concentration method.

In view of reports that coccidial infection may cause disease, and even severe mortality in lambs, it was decided to keep a group of lambs under observation to ascertain whether the infection might be responsible for either definite disease symptoms, or for loss of condition.

Fæcal specimens from the selected group of lambs were examined at

weekly intervals from birth till the animals were four and a half months old. The first oocyst was detected at one month old, after which the numbers rapidly increased till, at two months, some 15 oocysts per microscopic field ($\frac{2}{3}$ objective) were detectable in a sugar flotation specimen, and oocysts could be detected in the droppings even without the use of any method of concentration. The oocysts continued numerous till the animals were three months old, when the numbers began to decline, but even at $4\frac{1}{2}$ months they were still readily detectable. The group of lambs made normal progress and no evidence of pathogenicity was obtained.

The first oocysts appearing in the lambs answered to the description of *Eimeria parva,* being spherical, with no visible micropyle and about 12 microns in diameter. When the lambs were five weeks old this type of oocyst was mixed with specimens resembling *E. nina-kohl-yakimovi* (ovoid, no visible micropyle, about 20 microns by 15 microns) and forms resembling *E. arloingi* (ovoid, visible micropyle and polar cap, size about 30 microns by 20 microns). At this stage forms resembling *E. nina-kohl-yakimovi* predominated, but at seven weeks old the *E. arloingi* type was most prevalent. At eight weeks old oocysts of the *E. faurei* type (egg-shaped, with visible micropyle but no polar cap, about 30 microns by 20 microns in size) began to appear, as did also the large form *E. intricata* (ovoid, roughened oocyst with a thick wall, visible micropyle and polar cap, size about 45 microns by 33 microns), but these two types were never numerous. In the droppings from adult sheep the predominant type of oocyst was *E. arloingi,* but *E. intricata* was also usually present in small numbers.

Discussion

It has been claimed that coccidia are definitely pathogenic to lambs; and Becker (1934) states that " there can no longer exist any doubt that coccidiosis occasioned by *E. arloingi* in sheep and goats may be an extremely serious disease." He also says, in discussing Baloyet's investigations into the development of *E. nina-kohl-yakimovi* in the goat, that " the experiments left no doubt of the pathogenic properties of the parasite."

According to Gaiger and Davies (1938), *E. faurei* infection in lambs may lead to disease and a mortality of 3 per cent. if the resistance of the animals is reduced by adverse factors such as a railway journey, but the description given of the oocysts corresponds with those of *E. arloingi* rather than *E. faurei.* The same authors state that *E. intricata* may cause a mortality of 20 per cent. of the infected lambs. Yet it is certain that both *E. arloingi* and *E. intricata* were involved in the lambs under observation, without causing any recognisable loss of condition.

Carré (1928) investigated mortality in lambs associated with enteritis, diarrhœa and general unthriftiness and ascribed the condition to coccidial infection, but the same author in 1933 wrote that, although he had previously accused parasites (coccidia, giardia and amœba) of being responsible for the

troubles described, he had now come to the conclusion that the parasites could not be blamed for the enteritis, and that their development was the result and not the cause of the digestive arrangement. He ascribed the digestive derangement of the lambs under investigation to shortage of milk and consequent excessive grazing by the lamb before the digestive organs were sufficiently developed.

McFadyean (1896) describes a coccidial infection in lambs associated with a mortality of 10 per cent., and says that death usually resulted in forty-eight hours after the onset of symptoms, which were dullness, loss of appetite, diarrhœa and tympanic distension of the abdomen. Martin (1923) in the U.S.A. also accuses coccidia of causing severe mortality on one farm, describing symptoms similar to those described by McFadyean. These observations were made before much was known about anærobic infections of sheep, and there does not appear to have been much attempt made to exclude other causes of diseases.

Hall (1931) in Nigeria found 46 out of 52 sheep infected with coccidiosis, and noted that they appeared to be quite tolerant of the infection, and that no disease in sheep ascribable to coccidiosis had been recorded in Nigeria.

From the investigation discussed in this paper it seems that coccidiosis of sheep is very prevalent in Scotland, a limited number of observations suggesting that all sheep may be infected, and that lambs may contract infection with all the species to which pathogenicity has been ascribed without any disease symptoms resulting.

Similarly, in a limited number of examinations of pigs, 60 per cent. were found to be infected, both *E. debliecki* and *Isospora suis* being encountered, again in animals exhibiting no symptoms of disease.

As a result of these observations one is inclined to doubt the pathogenicity of coccidia to sheep and pigs, although the intestinal inflammation they produce may predispose to other infections. It must, however, be remembered that the same high incidence of infection exists in fowls and rabbits, and yet there seems little doubt that, under conditions causing mass infestation, disease and death may result in these latter animals.

I wish to record my thanks to Prof. Matheson and the staff of the Pathology department of the Royal (Dick) Veterinary College for allowing me to examine material sent to them for coccidia, and to Mr. McTurk, M.R.C.V.S., of Kelso, for arranging for the collection of droppings from a suitable group of lambs.

REFERENCES.

Becker (1934): *Coccidia and Coccidiosis*, Iowa.
Gaiger and Davies (1938): *Veterinary Pathology and Bacteriology*, London.
Carré (1928): *Rec. Med. Vet., 104*, 530.
Carré (1933): *Rev. Gen. Med. Vet., 42*, 665.
McFadyean (1896): *J. Comp. Path., 9*, 31.
Martin (1923): *North Amer. Vet., 4*, 142.
Thomson and Hall (1931): *J. Trop. Med., 34*, 369.

LACTATION TETANY IN EWES

By R. HUDSON, F.R.C.V.S.
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A NUMBER of ewes grazing on a field of clover were divided from the flock and brought a short distance to the farm buildings for clipping. They were placed in a small orchard almost bare of eatable grass, and had the run of various yards, sheds and the barn where clipping took place.

Two days from the commencement of operations five had gone down with symptoms of coma, semi-coma and paralysis.

The owner did not realise what the condition was until he had conversed with his brother, who, having had some ewes with similar symptoms, advised him to see me, so considerable time had elapsed before treatment.

The process of clipping had not induced the condition, because some were clipped and some unclipped, and there was nothing about the orchard or buildings that could be found which might have set up coma symptoms. Changes from digestible food such as roots or clover to old dead grass—fog grass, as it is termed locally—will give rise to impaction of the stomach and comatose symptoms. I have also seen similar effects produced by eating rhododendron. All these were absent.

The ewes had gone down in different places, two in the orchard, two in a yard and one on returning to the clover field just within the gate.

All but one recovered rapidly after calcium injection, and were able to walk about. The one which died was cold, scouring green, watery fæces, and looked like dying soon when I saw her.

Although able to walk about and join with others of the flock, one other also died a few days later, probably from pneumo-enteritis.

The injection given was:

Ca. chloride (fused), ℥f. half ounce.
Mag. chloride (fused), ℥iij.
Glucose (liq.), ℥vj.
Aqua @ pint.

This was divided into four injections and given subcutaneously.

What actually caused the condition is difficult to imagine, there being nothing to cause a flush of milk in the circumstances. They had been on the clover field some weeks and it was a good pasture, while there was nothing in the orchard likely to upset them. The change was the reverse of what one usually finds likely to induce lactation tetany.

Husk and Parasitic Gastritis in Lambs

After the prolonged period of wet and cool weather a few warm days soon

produced the diseases in a number of flocks of lambs. It was noticed that the lambs were doing well while the weather was cool, but about a week after the change many deaths took place attributable to diarrhœa.

Dosing with copper sulphate and carbon-tetrachloride had been tried, but did not appear to have been beneficial, for in one case 19 out of 100 lambs died in a week, and in another ten died in a few days.

I have often noticed that lambs when injected for parasitic bronchitis also benefit when suffering from diarrhœa (worms). It may be that the injection, absorbed from the lungs into the blood stream, may have some influence on the parasite embedded in the mucous of the stomach wall.

I think it is worth trying, particularly when all other vermifuges given by the mouth appear so useless.

Injection does not take a long time and is safe after a little practice. To-day 240 lambs were injected in 1 hour 40 minutes. All the lambs were being trough-fed on lamb food and I advised an increased amount along with hay chop and finely crushed cotton cake. Removal to clean pastures or, best of all, to a bare stubble—a field cleared of corn and without clover—is necessary whatever treatment is adopted.

MANAGEMENT AND NUTRITION IN RELATION TO THE HEALTH OF SHEEP

By PROF. R. G. WHITE, M.Sc.

THE management of sheep differs fundamentally from that of other farm stock in that they live entirely out of doors and in most cases receive little or no hand-feeding. In the case of other farm stock, food and shelter are provided to suit the requirements of the animal. Sheep—especially mountain sheep—which now form a very large proportion of our national sheep flock, must be adapted to their environment. This adaptation is perhaps the first aspect of management which calls for attention.

Surprise is often expressed that in a small country such as Great Britain there should be more than thirty different breeds of sheep. Possibly the number might be reduced with advantage, but the great variety is an indication of the way in which sheep have by selection—partly natural and partly artificial—been adapted to suit the circumstances of their own particular district. Where the need for such adjustment is not sufficiently recognised, or where the flockmaster has not sufficient skill or judgment to effect it, the results from the flock are not likely to be satisfactory, even if disease and financial loss are avoided.

In the extreme case of the mountain flock this is well recognised. The

ewe flock is of necessity a permanent one, and the combined skill and experience of the farmer and his shepherd are brought to bear in the purchase of the rams which are required from time to time. Size, type of wool, and all the various factors which constitute hardiness, have to be considered in relation to the nature of the grazing. Many of these qualities would be difficult to analyse or define, but in all probability they are related to nutritional needs, some extending throughout life, others merely at some particular period of growth. Certainly it is the case that many troubles only become serious when sheep are removed from their native districts and natural habitat to very different conditions.

With all kinds of livestock the care and skill of the herdsman, exercised from day to day, is of the very first importance, and the pre-eminence of British stock is very largely due to the aptitude and devotion of the various classes of stockmen. In no case is this more clearly seen than in the case of shepherds.

Until quite recently, veterinary surgeons were rarely consulted about sheep diseases, still less about the management necessary to maintain the flock in good health and, even now, shepherds are expected to have the knowledge and ability to deal with ordinary ailments of their flock. In accompanying a shepherd on his rounds it is remarkable to find how many and varied are the calls on his observation and skill. He has to look out for the first signs of foot rot, maggot attack and such common troubles. He may have to set a broken leg. He must be able to recognise the symptoms of scab, lamb dysentery and a great variety of other diseases. Above all, he must be quick to detect the signs which indicate that a change of pasture, or a thinning of the stock, or a little hand feeding is necessary if the sheep are to continue in the thriving condition which is the first essential of health. All these come on top of the routine work of feeding, lambing, castration, dipping, shearing, etc., each of which in itself calls for expert knowledge and sound judgment. In these days, no less than in times of old, the title "a good shepherd" is among the highest that any man can receive. The changes in agriculture which have taken place during the last thirty years have greatly affected the sheep industry. Arable sheep farming has largely disappeared. In place of the hurdled sheep, temporary flocks, often of a hill type, are kept on grass for the production of fat lambs. In place of the old, rather rigid systems based on the accumulated experience of generations, we now have in many districts much more casual management. To a great extent the troubles of which one hears so much—particularly perhaps infestation with internal parasites—are due to altered systems of management. Unfortunately, the change has also resulted in the loss of many of the old race of shepherds, whose skill and experience are as badly needed as ever.

Even the mountain flocks have not been unaffected by changing conditions. Two- and three-year-old wethers are no longer wanted, and their place has

been taken by increased stocks of ewes. These make a bigger demand on the protein and mineral supplies of the grazing, and it is certain that deterioration in the grazing leads to lessened resistance of the sheep to infections and infestation of a variety of types.

Nutrition

The effect of proper nutrition in enabling a sheep to resist infections and infestations is well seen in the case of internal parasites, where it is often difficult to decide whether the bad thriving of an animal is due to worm infestation, or whether heavy infestation with worms results from a low plane of nutrition and a consequent inability of the animal to resist attack.

Illustrations of more direct connection between nutrition and health is seen in the occurrence of some of the braxy-like diseases, where sudden changes in feeding result in intestinal conditions which lead to sudden death of the lamb or sheep.

The aim of the farmer and of the shepherd should be to keep the animals as far as possible in a steadily thriving and growing condition. In order to secure this, close observation and constant study of the animals is needed, particularly with a view to effecting a change of pasturage whenever necessary. A watchful shepherd does not need to be told when the sheep are ready for a change; they themselves will give him unmistakable indications, though, to a less competent observer, they would appear to have plenty of food and to be quite content.

The financial returns from the flock depend to a great extent on the percentage of lambs, and this, in turn, is determined very largely by nutrition. This can be very simply demonstrated by considering mountain ewes, which start life under the poorest conditions and are drafted down to good low ground when four or five years old. On the mountain itself the percentage of lambs may not average more than 75 per cent. The same sheep, taken down to a good low ground, will produce fully 100 per cent. of lambs in their first season, and in the second year will probably produce 120 per cent. or 130 per cent. The low percentage on the poor mountain grazing is partly due to the fact that some ewes may never be served at all, owing to the circumstances of the grazing and the short heat period, and partly to abortion or fœtal atrophy at an early stage. In both cases inadequate nutrition—using the word in a very wide sense—is probably the main cause. The well-known effect of the flushing of ewes is another illustration. A mild growing autumn results in a large crop of lambs even though the winter itself may be hard.

The importance of maintaining nutrition on a fairly even level as well as on an adequate plane is strikingly shown in "pregnancy" toxæmia, which has been a serious cause of loss in many districts this spring. Characteristically, it is found in ewes of mountain breeds and their crosses which have been kept on low ground for at least a year; it is hardly ever found in the same sheep

so long as they are kept on poor mountain grazing, and it does not often occur in their first year on low ground. Such sheep brought down to lowland are used for fat lamb production and have their lambs taken away at a comparatively early age, so that afterwards the ewes tend—on good pasture—to become excessively fat. If a hard winter follows, the rapid breaking up and utilisation of this reserve of fat appears to cause a condition which results in the well-known symptoms. The hard winter, and even semi-starvation, alone are not responsible; otherwise the sheep would suffer at least as severely on the mountain as on the low ground. Similarly, it is not merely the fat condition in autumn which counts, or the nature of the winter would not make any difference to the occurrence of the disease. Excessive fat and rapid depletion of the reserve both appear to be essential. Possibly the condition may be associated with the fact that the lambs are taken away from the ewe when she is still in full milk. It is, at any rate, noticeable that the disease is most commonly found in ewes of good milking qualities. In former days the practice of milking ewes after weaning the lambs was common in flocks of hill sheep, and possibly avoided a good deal of trouble from this cause.

Deficiency diseases of an obvious character are not very common in this country, though it seems likely that sway back and certains forms of "pining" are of this class. The "lambing sickness," which is akin to milk fever in cows, is also associated with deficiency of calcium.

To some extent the adaptation of our breeds to their environment probably accounts for the fact that less is heard of this class of disease than in other countries where imported breeds of sheep have been placed on all kinds of ground. The undoubted deterioration of our hill grazings and the introduction of new breeds to lowland districts may possibly bring to light unsuspected deficiencies. What has been said about the condition responsible for pregnancy toxæmia indicates the nutritional troubles which may arise when the sheep is moved to a completely new environment and subjected to a different type of management.

BRAXY

By EDWARD MORGAN, F.R.C.V.S., D.V.H.
Venezuela.

THIS disease of young sheep used to be the nightmare of sheep farmers in Scotland, Wales, Ireland and certain regions of England. To-day conditions are more favourable inasmuch as our knowledge of the disease is clearer and thus enables us to take prophylactic measures and so reduce the percentage of deaths in braxy farms from 30 per cent. to a very low figure. Probably this is the main reason why there has been so little publicity about the disease

in the veterinary and agricultural Press during recent years. Any student interested in the history of this disease may find abundance of information in the writings of Youatt, Nielsen, Jensen, Williams, Hamilton, Stockman, McFadyean and others. We are indebted in the first place to the majority of these scientists for the work they carried out in studying the ætiology of the disease. Many of them discovered the cause but did not produce, perhaps, a standardised vaccine the same as we have to-day. Although McFadyean's name does not figure so prominently as some names of the younger men of recent years in connection with the preventative side of this disease, yet we know that it is due to him to a great extent that others in this country were able to carry on the work so as to arrive at its present stage.

This disease of sheep is known by different names in different countries, and these names are known to vary even in the same country. In Cardiganshire it is known as redwater and autumn colic; Scotland as braxy or redbraxy and sickness; Ireland as braxy; England as redwater and struck; Germany, Denmark, Norway and Iceland as Bradsot or Bransot. The universal term, however, is braxy, which apparently means sudden sickness followed by sudden death.

In "The Book of Husbandry," a volume published in the sixteenth century, there is a description of a disease which apparently is braxy, but here it is termed the "blud." "There is a sykeness among shepe called the blud. The shepe that hath it wyl dye sodainly or he wyl stand styl and hange downe the hede and other whylie quake. If the shepherds can espy him, take him and rub hym about the hede and especially about his hears and under his eyen, and with a knife cut of his eares in the mydst and also let him bleede in a vain under his eyen, and if it bleede well he is lyke to lyve and if he bleede not, then kyll him and save his flesh, for if he dye himself the flesh is lost; and the skin wyl be far ruddier like blud more than another skin shal be, and it taketh most commonly of the fattest and best lyking."

Although the above description was written in the year 1575 it should appeal to everybody familiar with braxy as a good description.

Ivor Neilsen, a Norwegian, was the first to describe a bacillus as a probable cause of the disease. Professor Hamilton and others also concurred in this opinion. This organism was described by Neilsen in the year 1888 as a large, rod-shaped, non-motile, spore-bearing anærobic bacillus, found in the hæmorrhagic spots in the fourth stomach. At other times the bacilli had invaded secondarily other tissues of the body. Jensen confirmed Neilsen's findings from cases got from Iceland, Faroes, Norway and Sweden; Hamilton in cases in Scotland.

The distribution of the disease is very partial, inasmuch as it affects the west coasts. This can be said of Scotland, Wales, Ireland and several counties of England. Hamilton said that the parts of the countries where it prevails are all more or less under the influence of the Gulf Stream.

McGowan's opinion: The period of heaviest rainfall in the braxy districts, the autumn, coincides with the period of greatest incidence of braxy. So far, then, it would seem that rainfall, or to put it better a moist condition of the atmosphere, has some relation to the occurrence of the disease. On what part will the air contain most water vapour? Everything points to the west coast, and at the time of the year when the moisture is greatest. When braxy mostly occurs these circumstances are present, and, given a clear night, there will be a more copious fall of dew.

James Hogg, better known as the Ettrick shepherd, stated his view as follows: The disease commences about the middle of October. Any shepherd will tell you that it is on sudden changes from fresh weather to a frost its ravages are most felt. As a prevention he mentions: "Let them not be suffered to remain too late on the grassy parts below, but soon be put in motion towards the upper parts of their pasture."

Braxy generally makes its appearance with the first outbreak of white frost, and as a general rule lambs in good condition are the victims. The majority are taken ill at night and are found dead in the morning. Ewe lambs are less subject to the disease than wether lambs, especially if the former are in lamb.

A prolonged course of snow, rain or frost is not so unfavourable to the lambs as is a change from mild weather to frost or white frost, or on the other hand to rain or a sudden thaw after snow or frost, as any changes mean a chilling of the body, which seems to lower the resisting forces against the braxy organisms. There is a vast difference between the temperature in winter down in the lower ground and that higher up the adjoining hill, although the latter is more exposed to wind and storms. Cold air naturally falls while hot air rises, as instanced by the fact that hoar frost lasts longer down in the valley than higher up the hill. We know that on land which borders marshes and valleys, as McGowan stated, braxy is more prevalent than on land which is situated higher, such as hills. This accounts to a great extent why old ewes at evening fall generally move from the valleys and marshes towards higher ground to rest for the night, as it is dryer and warmer.

Symptoms.—The lamb moves uneasily about the field, then lies down, again suddenly gets on its feet. He may do this amongst the rest of the flock, but eventually he withdraws to a quiet corner of the field, and although now he does not seem to be so uneasy, yet the expression of the eye manifests pain. He is now in a high state of fever with a temperature of around 107°. There may be a discharge of froth or saliva from the mouth and nostrils. This sometimes, when the disease is at its last stages, is tinged with blood. There is now a distension of the abdomen. Eventually the lamb turns on one side and expires. The succession of symptoms lasts six and sometimes up to twelve hours.

Post-mortem.—As a result of a large quantity of gas which has been formed, the carcass soon swells up. There is a discharge of blood-coloured froth from the mouth and nostrils, not unlike a case of anthrax. The legs are stretched well apart owing to the distension of the body gases, and sometimes the least pressure causes them to burst through the abdominal wall. There are hæmorrhages in various parts of the body, such as the fourth stomach and surface of the heart. The lungs are congested, the liver and kidneys are softer than normal, the abdomen contains a large quantity of dark serous fluid—hence the name redwater. The skin is reddish in colour, still retaining this hue even when dried up.

Prophylaxis.—Previous to the advent of a vaccine against this disease, many farmers in Cardiganshire succeeded in reducing the mortality from around 30 per cent. to a very small percentage by feeding the lambs with a small quantity of corn, hay, etc., twice daily during the braxy period, also turning the lambs to seed fields, thus avoiding foul pasturage where the organisms are prevalent, which the lambs swallow along with this grass.

Braxy vaccine.—For several years some farmers have adopted the vaccine on farms where the mortality used to be as high as 30 per cent. but now has been reduced to about 2 per cent. as a result of vaccination. The vaccine which some of the farmers have been using is obtained from Messrs. Willows & Co. I think it would facilitate matters by quoting from their pamphlet:

"*Braxy vaccine* (*ovine*) is prepared from formalised whole cultures of ovine strains of Vibrion septique, B. Paludis and B. Chauvei, and contains the toxins and killed bodies of these organisms. Animal inoculation tests are made of the vaccine before issue to ensure that it contains no living organisms. The vaccine is indicated for the preventative inoculation against braxy, blackleg or 'struck' in sheep. It has no curative effect and should not be injected into sheep which are already infected with the disease. If there is reason to suspect its existence in a flock, the vaccine should not be injected unless preceded or accompanied by the inoculation of anti-serum.

"Preventative inoculation of unaffected sheep.—Inject subcutaneously a single dose of 5 c.c. about four weeks before the beginning of the braxy season."

In the autumn of 1937 two farmers in Cardiganshire who had already lost about 10 per cent. of their lambs consulted us re vaccinating the remainder of the lambs. After being advised that it was dangerous to vaccinate when the disease had set in, they still insisted on vaccinating at their own risks. Seeing that they were determined to do so, we advised them to keep the lambs indoors for several nights prior to inoculating with the braxy vaccine. These instructions were carried out. The lambs were then vaccinated and again kept indoors for several nights following vaccination. They had the satisfaction of having no further deaths from braxy that season.

Early in October of 1938 the lambs on one farm were vaccinated. All

went well without a single death from braxy until March, when 9 per cent. died. Deaths from braxy at such time of the year are rather unusual even when lambs are not vaccinated, as the most dangerous period is from October until January. In previous years the percentage of deaths averaged around 2 per cent. in vaccinated lambs, and these succumbed between October and the early part of January.

URINARY OBSTRUCTION IN YOUNG RAMS

By W. NAIRN, M.R.C.V.S.
Blairgowrie, Perthshire.

THIS condition is a frequent source of loss to sheep breeders who rear rams for stud purposes and subject them to excessive domestication.

I have occasionally met with the condition in castrated male sheep treated in a similar way for show purposes.

The trouble affects mainly ram lambs less than a year old and in my experience never occurs in older sheep, whereas calculi frequently do.

While an odd case may show occasional dripping of urine, usually when we are called to these patients there is complete arrest of urination.

The animal shows symptoms of pain-kicking at abdomen, lying quickly down, straining and grunting in a very suggestive manner.

Examination of the urethra will usually show an obstruction in the vermiform appendix of the penis, but the removal of that obstruction does not relieve the condition and further exploration of the urethra shows extensive blocking of the canal.

At post-mortem there is a urethritis and cystitis with a heavy deposit of urinary salts throughout.

The material in appearance looks like dirty sand and is simply the crystallised salts of the urine.

From the experience in human medicine where the same condition occurs it would appear to arise from the conditions to which ram lambs are subjected when house-wintered.

The animals are shut in sheds in late autumn without exercise and fed a dietary which usually contains too little fluid and under the circumstances is fed in excessive quantities.

Most of the cases occur within a few weeks of being housed and before the sheep have adjusted themselves to their mode of life.

In my district I have one feeder who feeds to his lambs a mash in a watery condition and his results justify his system of feeding.

Regular daily exercise, with more fluid in the food, the free provision of water and definite restriction of the amount of food until the sheep have

adjusted themselves to their changed conditions will almost entirely eliminate the trouble.

Discussing this condition with Prof. Boddie, he expressed the view that the chief factor in producing this condition was lack of fluid.

Certainly it would appear that every means which can increase the flow of urine in quantity and frequency will be advantageous. As stated earlier in these brief remarks, these cases are usually brought to our notice too late for therapeutic remedies to have any hope of success, but a better understanding of the condition may reduce the incidence considerably.

SHEEP

By G. MAYALL, M.R.C.V.S.
Bolton, Lancs.

In 1908 there were over 27,000,000 sheep in *Great Britain*. This year the total of sheep in *England and Wales* is nearly 18,000,000. In numbers sheep exceed those of any other domestic animals by millions. It deserves all the consideration for its welfare that can be given to it as no other animal surpasses it in returning profit to its owner.

The various classes of sheep are the Lowland, Down, Upland, and Mountain breeds, and they each require rather different methods of handling, management and feeding. It is important that supplies of mutton, lamb and wool should be plentiful and reasonable in price, and to ensure this grassland should be suitable and nutritious, as free from parasites as possible, and the aim to produce stock of good constitution be kept to the fore.

It cannot be stated that in past years proper attention has been given to curtailing losses in sheep life, and to scientific management of their rearing and feeding.

In recent years, however, there has been an awakening both in the veterinary profession as regards the diseases of sheep and in flock masters as to their breeding, rearing and management.

The Cahn Hill Experiments in Radnorshire are throwing valuable light on the improvement of hill grazings for sheep. They are showing the best grasses to improve the sward, how to deal with superabundance of bracken, methods of harrowing, manuring and sowing of seeds, and even the production of rape and turnips.

Mr. W. C. Miller, M.R.C.V.S., F.R.S.E., in The Veterinary Journal for April, 1932, discoursed in a very interesting and well-reasoned article on "Sheep-Sick" land. It ought to be read, digested, and acted upon by all sheep owners.

Dr. Theodor Oppermann, in his book on "Diseases of Sheep" (translated title), gives the following as the best pasture grasses: (a) On good sandy soil,

bird's foot trefoil, yellow clover, Swedish clover, white clover, kidney vetch, fescue, Timothy, etc.; (b) for light sandy soil, yellow clover, fescue, Timothy, bird's tares (vicia cracca), oats, etc.; (c) for hill pasture, the clovers, English rye grass, cocksfoot, fescue, etc.

So much for sheep husbandry. As regards research into sheep diseases, much advance has been recorded by various research institutes, and the veterinary professional workers are earnestly endeavouring to reduce the losses in sheep and lamb life.

Some research is also being conducted from the industrial side into the quality of wool, its production and staple, and if the "wool sack is next to the throne," the importance of keeping it healthy is evident.

THE DEPENDENCE OF THE SHEEP INDUSTRY IN AUSTRALIA ON SEASONAL CONDITIONS

By A. L. ROSE, B.V.Sc.

District Veterinary Officer, Cootamundra, N.S.W.

UNTIL recent years Australia has been almost exclusively a primary producing country and of her production, wool has always been the main factor in her annual income. Australia's annual income has fluctuated from year to year within very wide margins. Some of the factors causing this fluctuation are subject to control by the industry within the country and some are due to world influences. For example, full credit is due to the Merino flockmasters in the land for more than doubling the wool-carrying capacity of their sheep during the last sixty years. In N.S.W., the average fleece weight of greasy wool per sheep for the year 1876 was four pounds. This has shown a steady increase to its maximum of 8.8 pounds in 1927, around which figure it has since fluctuated.

In 1900 Australia's wool cheque was £13,500,000; during the ensuing drought it dropped to £6,000,000; it reached nearly £23,000,000 in 1913, only to drop again to £14,000,000 in the drought year of 1914. The all-time record was £60,000,000 in 1928 and 1937 but it has now receded to the £44,000,000 mark. Growers have little control over the price offered for their product and this has varied from year to year within wide limits, due to world economic conditions. Growers also have no control over seasonal conditions but it is within the power of many of them to take such measures as may be appropriate to meet these vagaries.

The sheep population of Australia now stands at some 113,000,000 of a world's total of 722,000,000, yet Australia's wool production amounts to 1,015,000,000 pounds of a total world production of 3,861,000,000 pounds. The wool grown in this country is of especial quality and consists of eighty-four per cent. Merino wool and only sixteen per cent. cross-bred wools. It is this fine Merino wool that is always in demand by millers and some of the difficulties associated with the production of it will now be examined.

These remarks refer especially to the State of N.S.W. but apply generally to the Commonwealth of Australia. In N.S.W. there is a coastal strip of country averaging about 40 miles in width in which the rainfall varies from sixty-three inches annually in the North to thirty-three inches in the South. Sheep raising is not attempted in these districts. Going inland, there is then a tableland strip in which the rainfall is from twenty-seven to thirty-four inches per annum. Thereafter the country slopes gradually away till the plains are reached about 300 miles from the coast. In the "slopes" districts the rainfall averages about twenty-six inches annually; thereafter the rainfall decreases with inland penetration until it is only eight inches when some 700 miles in from the coast. It is in the slopes and plains districts where the bulk of the sheep are carried and where seasonal changes exert their greatest influence. For example, the districts with low rainfalls may be visited by a severe drought for twelve months or more and in these circumstances the sheep are either moved hundreds of miles by road or rail to adequate feed elsewhere or feed in the form of grain and hay is transported to them. Either of these alternatives is a very costly proceeding. Last year drought conditions affected all the important sheep districts of the State so that movement to more favoured districts could not be made. This resulted in the greatest hand-feeding undertaking ever achieved by sheepmen. For months trainloads of fodder went to the stricken areas and the feed was carted out daily to the sheep on millions of acres of dusty, bare paddocks. This year it has rained intermittently for six months already and the whole country is transformed to a state of over-plenty. What, then, of the health and welfare of these sheep when they are subjected to such extremes?

Sheep, in common with other animals, thrive best when they remain on an even plane of body condition and changes from that equilibrium lead inevitably to all sorts of disease conditions, and the remainder of this article will consist of a consideration of some of these diseases.

Worm Infestation: Heaviest losses in this State are due to Trichostrongyles sp., Nematodirus and Ostertagia. When sheep are maintained in a good state of nutrition these parasites cause no ill-effects but in times of drought or over-plenty losses are immense unless much be done to combat them. It is indeed difficult to decide whether these parasitic troubles are at their worst in times of drought or plenty, for under both sets of circumstances nutritional conditions may be poor. When there is too much rain the feed

grows rank and lacks value and while it looks good its true value is reflected in the wretched condition of the sheep.

Foot-rot: This disease occurs in two forms in this country. In some very well defined districts there is prone to occur in almost any year a contagious type of foot-rot which is due to a specific organism, affects sheep of all ages and classes and generally in more than one foot. But in a year of continuous rain and some warmth we get a malignant type of foot-rot which is probably not contagious but which is very difficult to cope with. In a wet season like the present, probably fifty per cent. of flocks are affected with this malignant foot-rot, and if the sheep are left untreated more than half will become seriously affected. In this type it is usual for only one claw of one foot to be primarily affected and predisposition to the disease increases with age.

Entero-toxæmia: This disease, first put on a satisfactory footing by Bennets in 1931, is the cause of much loss in years of plenteous feed and is seldom seen under dry pastoral conditions. Last year it occasioned no loss but this winter many hundreds of thousands of sheep and lambs have been vaccinated as a preventive against it.

Blackleg: The writer had opportunity to observe a very great deal of this disease in sheep under drought conditions last year. The affected flocks were being hand-fed in dusty paddocks and always in the same place with a result that the feeding grounds became very badly fouled with droppings, food particles, etc., for it is the practice of the sheep to stand about on these grounds all day, awaiting the arrival of the truck. The sheep were being maintained in fair body condition at considerable cost and yet were dying in hundreds on some properties. Culture material was secured from swellings about the head and body and yielded Cl. chauvœi. It was considered that the continual concentration of the sheep on the feeding grounds made for a heavy bacterial contamination of the ground and that infection was gained per os. At all events, when the feed was scattered over irregular places in the paddocks and the sheep were made to feed on different grounds each day, mortality usually ceased.

Fluke and Black Disease: Cases of chronic fluke infestation are seldom seen in this country now because sheep in affected districts are regularly treated with carbon tetrachloride. The huge annual loss from black disease is also a thing of the past now that we have a one hundred per cent. efficient alum-precipitated whole culture vaccine, but there is one aspect of the fluke problem that has not yet been conquered and that is the occasional heavy seasonal loss from acute fluke infestation. We call it "acute fluke" when sheep die as a result of sudden invasion of the liver by many immature flukes, forms too small to be killed by standard methods of dosage. About every eight or ten years a season occurs in which rains continue well into the sum-

mer, keeping large areas of land wet under seasonable conditions favourable to snail propagation and about a month or two later we have our losses from acute fluke. The country is often too extensive to allow of drainage and snail destruction and the use of large doses of carbon tetrachloride (sufficient to kill immature fluke) is not popular owing to the unfortunate heavy mortalities which occasionally follow the use of this drug.

Pregnancy Toxæmia: In this country the lambing ewe must be the subject of special care or considerable loss may result. In the last drought it was found that big ewes could be kept during their period of gestation in a splendid state of body condition on a ration consisting of half a pound of good grain and half a pound of good hay or chaff. Such ewes lambed eighty per cent. of lambs which were reared under the same conditions to bring high prices. But the vast majority of flocks received ever so much less feed than this, the ewes survived and lambed a small percentage of miserable lambs. It has always been found, however, that when the plane of body condition is allowed to drop when the ewe is approaching lambing, pregnancy toxæmia may be induced. This disease is therefore principally seen under poor pastoral conditions and in times of drought it has been the cause of the loss of many thousands of good ewes. The lesson has been taught, however, and in recent years much attention has been paid to keeping up the body weight of the ewes as they approach lambing. When loss does occur from this cause it is nearly always possible to control it by making an improvement in the quality of the feed, be it natural or artificial.

Anthrax: The grass usually dries off in this State in October and the seeding root grasses run up to seed. This seed is shed in November and much of it is in the form of sharp, penetrating spikes. Our anthrax outbreaks in sheep almost always coincide with the shedding of this seed and it is presumed that the spore is conveyed under the sheep's skins mechanically by the seeds. Indeed there was a season several years ago in which summer rains followed the first seeding so that a second seeding occurred and in that year we experienced two crops of anthrax outbreaks. In a big year when the plains are covered with waving masses of grass we must anticipate an increase in our anthrax outbreaks and conversely in seasons where the grass and its seed have not flourished, there is little sheep mortality from anthrax.

Much more could be written about the many diseases which come and go with the seasons—all for this special reason. Much is now being done in this country to meet these losses. The conservation of fodder in times of plenty to meet the times of stress is being developed, though much still remains to be done in this direction. To meet the actual bacterial and parasitic diseases induced by seasons much has been done on the research side to develop some form of therapy and with very outstanding success. The difficulties of administering drugs and vaccines to very large numbers of sheep have been overcome in quite ingenious ways and an automatic device

is now the principal instrument in use when some thousands of sheep have to be treated. The "drenching" guns, as they are called, are capable of maintaining a continuous flow of the drug in such an efficient manner that it is possible to dose from 600 to 800 sheep per hour with carbon tetrachloride. Moreover, these instruments have been made proof against the corrosive action of copper sulphate so that the highly efficient copper sulphate-nicotine sulphate combination can now be administered by these means. The same instruments have now been adapted for the use of vaccines and now we vaccinate millions of sheep annually against such diseases of black disease and entero-toxæmia by quickly administering the dose through the skin of the back or side as the sheep stand penned in a race. By this means an operator can vaccinate as many as 800 sheep per hour single-handed.

There now exists in this country a wholesome understanding between the sheepowner on the one hand and the veterinary profession on the other. This has led to good opportunities for investigation and research, to the evolution of protective methods and to their ready adoption by the stock-owning public.

SALVING SHEEP

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OFFICIALS who attend sheep dippings frequently hear debates over the advantages of salving compared with dipping.

Many of the older shepherds maintain that salving was more effectual and some have even averred that the present-day sheep dips are the cause of sheep scab.

In the days when salving was practised, after the harvest was over and other crops were stored, a few men were set aside for the special duty of salving, and they continued at it each week-day for about a month, commencing in the middle of October.

A commodious outhouse was allotted for the operation and the men sat from morning to night patiently shedding the fleeces of the sheep and anointing each parting with the specially prepared salve.

Those who rubbed in the salve were called "scab or sheep doctors," a term still found in North of England directories.

The usual composition of the salve was 16 lb. of butter to 4 quarts of tar. This quantity was sufficient to salve 35 to 40 sheep at a cost of about sixpence per sheep.

The tar used for the purpose came from America, and in Westmorland was termed "roamy," being of a fatty unctuous nature and with the consistence of very thick molasses.

The salvers could not avoid the material getting on to their clothing, and were very sensitive about this, and it was not advisable to mention the word "salving" in their hearing.

When salving was taking place lads would call the salvers "lousy lurriers," "ked hunters" or "greasy lurriers," and on chase being given and the culprits caught, swift and drastic punishment was meted out as the culprit was placed face downwards on the "settle" and whacked with a tarry board.

A good man would smear 10 to 12 sheep in a day and the remuneration was twopence per sheep.

Some would boast that they could salve 16 sheep, but an old farmer would say "more folk would ask who salved them than how long it took them."

In the short days candlelight was necessary and the writer (possessed of a decided flare for antiques) has frequently cast covetous glances at local-made iron candelabra that he has encountered during his visits to sheep farms.

In some districts a tallow candle was stuck in a band on the forehead for illuminating the work of salving, but by this method the salver had to endure much discomfort from the melted tallow droppings as he toiled at his sheep stool.

Old customs die hard and there is still a practice in districts with a heavy rainfall of adding seal or whale oil to the present-day dipping fluids.

When sheep have to be handled after immersion in such oily baths it is a very unpleasant duty and there is a possibility that the addition of oil diminishes the anti-parasitic properties of the approved sheep dipping preparations.

The oil appears to be added with the idea of assisting the waterproofing of the fleece.

Veterinary inspectors who have had experience of handling large numbers of sheep certainly do desire no reversion to the salving of sheep.

Abstracts

SOME OBSERVATIONS ON A DISEASE OF SHEEP ON DARTMOOR *

By J. B. E. PATTERSON

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ATTENTION was called to a peculiar disease of sheep on Dartmoor eighteen months after two flocks of Pedigree Welsh and Shetland sheep were brought to Hedge Barton Farm, Manaton, in 1934. On inquiry it was found that the

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disease is common to the locality, but confined to an area on the granite soils of the Moor, and that it has been prevalent for many years. It occurs only on certain farms in the locality, or even on certain fields on one farm, and the intensity and rapidity of onset vary from field to field.

Symptoms.—The affected sheep have a general unthrifty appearance: the fleece becomes staring and harsh to the touch, the ears droop and the face takes on a characteristic "grey" look. In the early stages the eyes become inflamed. The animals become gradually weaker and emaciated; they stagger and finally lose the use of their legs. After any slight exertion the rate of breathing and of heart-beat increase greatly. On examination after death a general state of malnutrition is found, and the intestines are often infested with parasites, chiefly *Hæmonchus contortus* and *Ostertagia circumcincta*. The liver is very fatty and oily[1] and is deficient in mineral matter.

Breed.—All breeds of sheep do not suffer to the same extent. The Welsh breed is very susceptible, and in the autumn of 1935 all the lambs were affected. Shetlands appear to be immune, or much more resistant, as no instance of "pining" has been found among the flock in five years.

Climate.—The farms on Dartmoor that are most subject to the disease are at an average height of about 1,100 ft. above sea-level. The annual average rainfall is about 60 in. According to local shepherds the trouble is most common in a wet season following a dry one.

Soil.—In Devonshire there seems to be, for want of evidence to the contrary, a connection between soil and "pining" in that the disease is found only on granite soils, where the cure is effected by moving sheep to other pastures on soils of very varied geological type. A typical description (abbreviated) of a "pining" Dartmoor profile is:

0—10 in.	Greyish-brown gritty light loam.
10—21 in.	Slightly yellowish-brown loose light loam. Granite fragments.
21— 8 in.	Coarse angular granite brash with large fragments of rock.
28+ in.	Coarse-grained granite.

These soils show no visual evidence of podsolisation; they occur on moderately steep slopes, and the constant wash of soil has prevented the development of a mature profile.

Typical mechanical analyses of Dartmoor soils associated with "pining" are given in Table I, together with corresponding figures for healthy lowland soils in Devonshire.

The healthy soils derived from shales are decidedly heavier in texture than the "pining" soils, but the Maidencombe conglomerate soil is an exception.

Determinations were made of phosphoric acid soluble in concentrated hydrochloric acid and 2 per cent. citric acid, potash soluble in concentrated

hydrochloric acid and N/2 acetic acid, nitrogen, exchangeable calcium, and pH. On the whole, the healthy soils contained more phosphorus and potash, no doubt owing to their being cultivated lowland pastures. There was no significant difference in pH or exchangeable calcium.

TABLE I. *Mechanical analysis of Healthy and Unhealthy Soils.*

	Sick soils			*Healthy soils*		
Description	*Dartmoor granite*	*Wingstone granite*	*Tigley shale*	*Yellow shale and diabase*	*Beenleigh shale*	*Maidencombe conglomerate*
Coarse sand ...	33.73	26.99	9.48	15.48	20.44	30.67
Fine sand	21.58	33.97	13.28	9.08	14.19	27.17
Silt	14.30	13.55	24.85	24.20	25.30	16.35
Clay	14.43	17.25	39.05	36.33	24.45	21.38
Loss on ignition ...	16.95	13.76	18.52	19.50	22.30	8.18
Loss by solution ...	4.46	3.79	3.48	5.39	4.15	2.86

Eleven samples each of healthy and sick soils had a mean content of 2.14 per cent. and 1.43 per cent., respectively, of iron soluble in 5 per cent. oxalic acid. The difference between these means is, however, not statistically significant.

Causes.—Among the suggested possible causes of "pining" are (*a*) parasites, (*b*) poisonous plants, and (*c*) mineral deficiency.

The fact that different breeds of sheep are affected in a different manner on the same farm appears to point to nutritional factors rather than to parasites, since, as far as is known, parasitic infestations are not specific to breeds. Similarly, it is unlikely that the poisonous effect of plants on cultivated pastures would be different with the two breeds of sheep.

On the other hand, mineral deficiency, either alone or in combination with parasites, appears to be the most likely cause, and it was investigated first. The rapidity of the recovery of sheep when moved to lowland pastures is striking and is inexplicable on the view that parasites are the sole or principal cause of the poor state of health of the sheep. The parasitic infestation is possibly the result, and not the cause, of the low state of health, which allows a worm-burden tolerated under ordinary conditions to have effects which would normally be resisted. This point requires investigation.

It is possible that the immunity of the Shetland breed may have its roots in the similarity of the climatic and soil conditions of Dartmoor and the Shetland Islands. Both are fairly high in altitude and have soils of very free drainage on granite. The geological materials from which both areas are formed are very similar, comprising granite, mica- and hornblende-schists, and New Red Sandstone deposits.

The geological materials to be found in north and mid-Wales, on the other hand, consist of shales and limestones similar to those occurring on the lowlands of south Devon.

Cure.—The only apparent cure on Dartmoor is to move the flock for

two or three months in the autumn and winter to lowland farms on soils of heavier texture. On certain farms near the edge of the Moor it is claimed that movement of the flock to another field on the same farm, or the feeding of turnips, may bring about a temporary cure.

Similar diseases elsewhere.—Similar symptoms of diseases of sheep known as "pine" and "bush-sickness" have been described in recent years by Russell Greig, Dryerre and others in Tiree[2], M'Gowan and Smith in the Cheviots[3], and Askew and Rigg in New Zealand[4]. In 1794 Fraser[5] described a disease of sheep and cattle on Dartmoor which resembles that described above. The movement of animals to other ground for cure is common to [3], [4] and [5], whilst the feeding of turnips for the same purpose is given by [3] and [5]. Differences in the susceptibility of breeds were noticed in the Cheviots[6], as were also the effects of dry and wet seasons[3]. Similarity in soil conditions is found in New Zealand with regard to texture and parent material[4][7][8], and the solubility of iron in 5 per cent. oxalic acid has been used as an index of incidence in New Zealand[9] and Tiree[2].

Treatment.—As mentioned above, the treatment followed on Dartmoor has been to move the flocks on to lowland pastures for a period. Fraser[5] says that in 1794 an alternative was to give "drafts of red loam, mixed with water." It is interesting to note that the giving of a drench of soil from healthy pastures as a cure is the same treatment as that found by New Zealand workers to be effective in the Nelson area[10][11]. The beneficial effect of feeding sheep with turnips by folding on the growing crop may be ascribed to the ingestion of quantities of soil larger than those which are obtained in the grazing of pasture. The work of Underwood and Filmer[12] called attention to the curative properties of cobalt in the soil, and other workers, in particular Lines[13], Marston[14], and Askew and Dixon[15], have shown the effectiveness of giving cobalt salts as a supplement. Kidson[16] has studied the cobalt-content of New Zealand soils by determining the percentage of cobalt extracted by concentrated hydrochloric acid. The variation is wide—0.3 to 380 parts per million. She concludes that, in general, soils affected with stock ailments have comparatively low cobalt-contents, but that there are notable exceptions; and that the determination of the cobalt-content of a soil is not a dependable guide to the necessity for the giving of cobalt supplements to stock.

Experimental.

Determinations of the cobalt-content of soils from unhealthy and healthy areas in Devon have been made by the method of Kidson, Askew and Dixon[17], and a summary of the results obtained is shown in Table 2. (See also Kidson[18] and Patterson[19].)

All figures refer to the cobalt obtained by extraction with concentrated hydrochloric acid. The mean value (4.0 p.p.m.) in unhealthy soils is higher than that found by Kidson (less than 2 p.p.m.).

TABLE 2. *Cobalt-content of soils in Devonshire.*

Unhealthy soils from Dartmoor.	Mean of 18 samples, 4.0 p.p.m. Co.
" " "	Range of values, 1.9-6.7 p.p.m. Co.
Healthy soils from Devon.	Mean of 12 samples, 19.6 p.p.m. Co.
" " "	Range of values, 13.0-32.8 p.p.m. Co.

Kidson[18] has pointed out that the cobalt-content of a wide variety of soils is related to the magnesium-content of their parent rocks, and some observations in south Devon appear to confirm this view. Table 3 shows the relative magnesium-contents of granite from Hay Tor Quarry (about one mile from Hedge Barton Farm) and of shales of palaeozoic age.

TABLE 3. *Magnesium-contents of Parent Rocks.*

	Granite [20] *Hay Tor Quarry* per cent.	*Shale* [21] *Delabole* per cent.	*Shale* [21] *Bangor* per cent.	*Shale Marley* per cent.
MgO	0.14	1.09	2.20	2.68

The cobalt-content of the Hay Tor sample of granite is given as 0.00 per cent. Presumably the actual content is extremely small and the high content of the soil derived from granite is due to concentration by weathering. The shale from Marley contains 15 p.p.m. cobalt and the soil derived from it 26.0 p.p.m.

Attempts have been made[22] to correlate the cobalt-content of pastures with the frequency of incidence of sheep ailments. It was found that healthy pastures in the Nelson district of New Zealand contained, in general, a higher percentage of cobalt than the unhealthy pasture at Glenhope. The mean of 14 samples from healthy pastures is 0.31 p.p.m. and of 12 samples from unhealthy pastures is 0.20 p.p.m. Co. All figures are calculated on a dry-matter basis. The feeding of supplements of cobalt of the order of 8 mg.—0.4 mg. Co per week has been completely successful in overcoming bush-sickness at Glenhope and Morton Mains in New Zealand[15].

Attempts were made on Dartmoor, before the New Zealand papers were published, to increase the nutritive value of the herbage by giving dressings of slag at 10 cwt. per acre to the pastures. Groups of sheep were kept on slagged and unslagged pasture without effect. Both groups became badly affected in the late summer, particularly those on the slagged land, and it was necessary to shift the adult flock to a lowland pasture at Rattery in order to save it. The recovery was strikingly rapid. In less than ten days sheep which had had to be carried to the lorry to be brought to the change pasture were strong and very active.

In the autumn the lambs became weak and showed the characteristic symptoms.

It was decided that a preliminary trial with mineral supplements should be carried out with a view to making a large-scale experiment in the following year. Owing to the lack of grass a daily ration of cake was fed to the lambs,

of which twenty-four were available for experimental purposes. These were divided into two groups, and the cake of one was sprayed with a solution of cobalt chloride and manganese and zinc sulphates in quantity to give 7 mg. Co, 14 mg. Mn, and 1.365 gm. Zn per lamb per week. The cake fed to the other group was sprayed with an equal volume of distilled water.

The mineral group recovered and increased in weight more rapidly than the control group at first, but at the end of two months both groups were of equal live-weight at the mature stage of 50 lb. The animals in the mineral group were, however, more healthy in appearance than those in the control group.

It was intended to follow up this preliminary work with a full trial, using supplements of cobalt and other minerals, singly and in combinations, but the work was being done on a commercial farm and became too expensive. The flock was sold off and no more work could be done.

The observations and facts here recorded are admittedly very incomplete, but are published for possible use by future workers who can command more ample resources.

Summary

1. The symptoms of a disease of sheep on Dartmoor are described, and their resemblance to those of "pine" in Scotland and "bush-sickness" in New Zealand is shown.

2. The climatic, topographical, and soil conditions of regions where these diseases are found are compared, and figures for the available iron and the cobalt in soils and pastures are given. It is shown that there is a possible connection between the incidence of and recovery from the disease and the cobalt-content of soils.

3. The mineral-content of the herbage from sick and healthy areas appears to bear no direct relation to onset or recovery.

4. The rapid recovery of sheep when moved on to lowland pasture points to causes other than parasitic.

5. Preliminary trials with mineral supplements of cobalt, manganese, and zinc have given indications of the effectiveness of these elements in controlling the disease.

6. Owing to the enforced abandonment of this work the observations and results here recorded are offered to any worker who may be able to continue the investigation.

REFERENCES.

(1) H. Ramage, *Nature*, 1936, *138*, 762.
(2) J. Russell Greig, H. Dryerre, W. Godden, A. Crichton, and W. G. Ogg, *Veterinary J.*, 1933, *89*, 99.
(3) J. P. M'Gowan and W. G. Smith, *Scottish J. Agric.*, 1922, *5*, 274.
(4) H. O. Askew and T. Rigg, N.Z. Dept. Sci. & Indust., 1932, Res. Bull. No. 32, p. 5.
(5) Robert Fraser, A General View of the County of Devon, with Observations on the Means of its Improvement, 1794, p. 54.

(6) Editor, *Quart. J. Agric.*, 1831, *2*, 706.
(7) B. C. Aston and R. E. R. Grimmett, *N.Z. J. Agric.*, 1927, *34*, 289.
(8) L. I. Grange and N. H. Taylor, N.Z. Dept. Sci. & Indust. Res., 1932, Bull. No. 32, p. 31.
(9) T. Rigg and H. O. Askew, ibid., p. 52.
(10) —— *Empire J. Expt. Agric.*, 1934, *2*, 1.
(11) —— ibid., 1936, *4*, 1.
(12) E. J. Underwood and J. F. Filmer, *Austral. Vet. J.*, 1935, *11*, 84.
(13) E. W. Lines, *J. Council Sci. Ind. Res. Austral.*, 1935, *8*, 117.
(14) H. R. Marston, ibid., 1935, *8*, 111.
(15) H. O. Askew and J. K. Dixon, *N.Z. J. Sci. & Tech.*, 1936, *18*, 73.
(16) E. B. Kidson, ibid., 1937, *18*, 694.
(17) E. B. Kidson, H. O. Askew, and J. K. Dixon, ibid., 1936, *18*, 601.
(18) E. B. Kidson, *J. Soc. Chem. Ind.*, 1938, *57*, 95.
(19) J. B. E. Patterson, *Nature*, 1937, *140*, 363.
(20) E. G. Radley, Chemical Analysis of Igneous Rocks, etc., Geological Survey, 1931, p. 3.
(21) Thorpe's Dictionary of Applied Chemistry, 1926, *6*, 1936.
(22) H. O. Askew and P. W. Maunsell, *N.Z. J. Sci. & Tech.*, 1937, *19*, 337.

PARASITIC DISEASES OF FARM ANIMALS*

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THE close association between parasitic diseases and animal nutrition will be more easily understood if we carry ourselves back in imagination to the beginnings of man's interference with the balance of Nature. Let us admit at the outset that throughout the stretches of evolutionary time everything ran *comparatively* smoothly until man made his appearance, and that the advent of his intelligence was of the nature of a calamity to all other zoological species.

We may suppose that early man was in some respects a gentleman, in that he spent his days in hunting and his nights in feasting. No doubt he sometimes returned from his hunting expeditions with young animals for his children to play with, and later, recognising the possibilities of providing through this means for his own comfort and security, he contrived to encourage the breeding of certain useful animals in captivity and so set himself the task of protecting his tame animals from other beasts and providing for their food requirements. Through some such process as this primitive man came to exchange what must have been a very dashing if uncertain sportsman's life for the humdrum cares of the husbandman.

If we would lay the blame for the present prevalence of parasitic disease

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upon any particular individual it must be upon that early genius who was the first to think of husbanding the patches of grazing near his own home, fencing them round to keep his domesticated animals from wandering, and reserving the choice grass for them alone. That man may be regarded as the first agricultural sinner, who deranged the natural order of things in the Garden of Eden, where the grazing animals had hitherto lived in peaceful equilibrium with their parasites.

One might describe the change by saying that the primordial state was one of harmonious community of happy worms in happy sheep, but since man's interference upset the balance one only too frequently sees a threatened annihilation of both. A satisfactory readjustment bringing the level of parasitic infestation within the tolerance of the host still awaits discovery.

It is generally admitted among graziers that the diseases caused by parasitic worms are the most economically important of all with which they have to contend. Most of us have been brought up to think that parasites are nasty creatures and that their only product is disease, so that it may come as a surprise to many to know that the very parasites which may give rise to so much trouble by excessive multiplication are normal inhabitants of healthy animals, guests of their alimentary tract. Disease is as harmful to the parasites as it is to their hosts, since it may lead to the death of the whole community. Parasitic disease is, therefore, to be regarded as a flaw in the environment and a departure from the primitive conditions to which the parasites had adapted themselves, rather than to a predaceous attack by small creatures upon a larger one.

So long as the number of worms in an animal remains reasonably and "naturally" small, the balance of the ecological unit is maintained and a harmonious relationship continues, but disease follows where the numbers of the parasite community become excessively great. The increase of parasites, as we shall see, is essentially linked with progress in the improvement of pastures, worm diseases are man-made, and the artificial readjustment of the balance between the grazing animal and its parasites looms very large in the practical problems of animal production.

This readjustment will come only through a detailed knowledge of the reactions of the parasites both during their free life in the pastures and during their parasitic life in the grazing animal.

Mechanism of the development of parasitic disease among grazing animals.—The outline of the life-history of the parasites is comparatively straightforward. The adult female worms, situated in the lumen of the intestine, lay eggs which pass out of the grazing animal and on to the pastures; in the course of about twenty-four hours these hatch and give rise to minute larvæ which, during the course of a week, cast their skin twice and reach the infective stage at which they are ready to proceed with parasitic life as soon as they happen to be picked up by a suitable grazing animal.

For the proper understanding of the development of worm diseases there are three important points which require special consideration. The first of these is *the inability of parasitic worms to multiply in the body of the animal in which they are living.* This constitutes an important peculiarity in the propagation of worm diseases, distinguishing them from the kind of disease caused by bacterial or protozoan parasites, which are capable of multiplication within the body of the animal in which they are living. Where parasites can multiply in this way there is some reason for supposing that the initial infection is a most important step in the disease-producing process. If, however, every individual parasite requires to be picked up from outside, as is the case with parasitic worms, the relative importance of the initial introduction of infection appears to be very little indeed, and is of no practical consequence at all where, as with the parasites under discussion, all communities of animals, both healthy as well as diseased, are invariably infected. In such an instance as this it must be concluded that the *environment* of the grazing animal, which so largely governs the increase of the parasites, is of paramount importance.

The second important point to consider is *the remarkable egg-producing powers of the worms.* The egg production of some parasitic worms is numbered in tens of thousands daily per individual female, and although most of the worms with which we are concerned probably produce less, the daily output of eggs by infected grazing animals is very great indeed: a healthy sheep carrying an infection of trichostrongyles may pass some 200,000 to 400,000 eggs daily, and a diseased sheep between 9,000,000 and 30,000,000; a healthy horse carrying only a light infestation of strongyloid worms passes 1,000,000 to 2,000,000 eggs daily, and a diseased horse over 50,000,000. There is thus seen to be ample opportunity for the transmission of large numbers of worms under crowded grazing conditions, and this enormous output of eggs, which earlier in evolutionary time was developed to ensure the continuity of the species, is quite unsuited to present agricultural conditions.

The third important point to consider is *the longevity of the infective larvæ of the worms in the herbage.* In the infective stage the larvæ are ensheathed in a second outer skin, the result of incomplete moulting, and in consequence are endowed with great powers of resistance against cold, dryness, or other adverse forces acting upon them. They are also able to survive for an inconveniently long time in the herbage; patience may be said to be one of their vices, for some of them can wait twelve months, or even two years in exceptional cases, for a passing host.

Evil effects of overcrowding.—In view of the enormous output of eggs, even by healthy animals, and the longevity of the larvæ on the pasture, it is clear that under agricultural grazing conditions there is liable to be a more or less rapid accumulation of infective material during the whole of the time that a pasture is occupied by grazing animals; and the evil effects of over-

crowding may now be more fully appreciated. It is obvious that the more animals that are put on to a field the more eggs will be disseminated, and the more infective larvæ be picked up: but the rate of increase is actually even greater than it appears, as it has been shown that there is a tendency for the parasites to increase as the *square* of the number of animals per unit area.

With all these forces in favour of numerical increase of parasites, one may well ask by what miracle the animals in our fields ever escape parasitic disease. The logical explanation of miracles has always been a stiff proposition, and much of the research work which is being carried on at the present time into the helminthiases of grazing animals may be regarded as an endeavour to explain this one.

Proceeding along the mathematical line, as in the analysis of the effects of overcrowding, we might consider some such unit as "sheep-per-acre-week" with a view to easy comparison of the amount of grazing sustained by various pastures: the influence of factors other than the grazing animal and its particular kind of parasites upon an increase of parasite population is so great, however, that a unit such as this would be quite useless for estimating the amount of infection in a field. Indeed, these third factors are of such dominating importance that it is hoped that a thorough understanding of their influence may enable us, some day, to bring the worm diseases of grazing animals under our control.

The "Third Factors" Governing the Increase of Parasitic Worms

(*a*) *Immunity.*—First of all there is the question of immunity, i.e., the resistance of the grazing animal to the development of the infective larvæ which it acquires while grazing on infected herbage.

The study of the immunity reactions to worm-infection has attracted much attention among workers in parasitology during the past decade, and many interesting points have been revealed. In general, it may be stated that adult animals are much more resistant both to the results of worm-infestation and to the actual development of the worms than are immature animals. Although adults are never entirely immune and usually carry a few parasitic worms throughout their lives, their resistance to new infection is very considerable, so that they may be able to graze with impunity under conditions that would lead to fatal disease among susceptible *young* animals.

This resistance is not absolute, however, and poor feeding or a deficient diet, combined with a high rate of intake of infective larvæ, will break down the resistance, and severe disease frequently occurs among adult stock under those circumstances.

(*b*) *Regular Anthelmintic Medication for the Destruction of Adult Worms.*—Since we are dealing first with the inhibiting influences upon the

parasitic stages of the worms, it will be convenient to make a short mention here of the use of the medicaments known as anthelmintics.

The control of parasitic worms by the use of *cheap, safe, easily administered and effective* drugs is the means of control most favoured by the farmer, who finds the restrictions imposed on him for the control of the parasites by other means most irksome, and difficult to fit in with the management of his stock. At the end of the last century, upon the advice of a South African veterinary surgeon, the farmers there began to use copper sulphate for the control of the "twisted wireworm," and so saved the South African sheep-farming industry, which was threatened with ruin as a result of the enormous numerical increase of that parasite.

Were it not for regular dosings with copper sulphate, which is now used all over the world for the limitation of the increase of the twisted wireworm, it would be impossible in many parts to rear sheep. This medicament is the only one yet known for use in grazing animals that answers the requirements of being cheap, safe, easily administered, and effective; but, unfortunately, it only serves against this one species of parasitic worm.

Our knowledge of anthelmintic medication as a means of controlling the worm population and preventing disease is therefore very limited at the present time and, with the exception of the twisted wireworm and one or two other species, we must depend upon other measures for preventing the excessive multiplication of the worms.

(*c*) *Factors Acting upon the Larvæ in the Pastures.*—The factors influencing the increase of the parasites next to be considered are those concerning the development of their free-living stages on the ground. These may conveniently be considered under four headings:

1. Factors affecting the *development* of larvæ in the pastures.
2. Factors affecting the *longevity* of the larvæ.
3. Factors affecting the relative concentration of larvæ in the pastures and their *accessibility* to the grazing animal.
4. Factors affecting the *disappearance* of larvæ from the pastures.

(1) *Soil moisture* is popularly supposed to have a marked influence, and "wet" pastures are usually thought to be "wormy" pastures. There appears to be no valid reason for this supposition, however, and it may reasonably be argued that "moist" pastures are just as dangerous as "wet" ones for the development of diseases caused by nematode worms, the only real difference being between "moist" pastures and "very dry" pastures such as occur in arid countries.

Drought produces rather an interesting result in that it inhibits the development of some species of larvæ without destroying them, the embryonated eggs remaining viable but not hatching until moister conditions

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recur. This sometimes leads to the accumulation of a large amount of potential infective material on the pastures during times of drought and a mass release of infective larvæ when wet weather appears. This sequence of weather conditions occasionally leads to the widespread appearance of worm disease in apparently epidemic form.

Rain assists larval development by supplying abundant moisture, and although heavy rain washes many larvæ off the herbage, they soon climb on to it again.

Frost has no action whatever in destroying the infective larvæ, but through inhibiting their development its effects are similar to those of drought in that the accumulation of potential infection is followed by a mass development of infective larvæ as soon as warmer weather conditions recur—rather like the sudden invasion of our roads by week-end motorists as soon as the weather decides to be warm.

Trampling of fæces into the soil, such as occurs where sheep are penned together, is distinctly favourable to larval development.

(2) Since the most lethal of the natural forces acting upon the ensheathed resistant larvæ is dryness, *the relative moisture of the soil and of the atmosphere* doubtless play a part. Observations made at Weybridge have shown that the larvæ which climb high into the herbage may die within 24 hours in dry weather, but those which remain close to the ground retain their vitality for months. The *nature of the herbage* is also of some importance, the longevity of the larvæ probably being greater in thick matted herbage which keeps them near to the ground than in a first or second year's grass ley, or in clover where they are able to climb away from the soil and come into contact with the drying influence of the air.

(3) *The amount of herbage* in a field has a marked influence on the number of infective worm-larvæ picked up by a grazing animal, an important point which had not been recognised until some observations on the larval-content of pastures were carried out at Weybridge, necessitating the employment of the unit "larvæ per pound of herbage." It was then realised that the herbage may be regarded as a diluent to the larvæ; where herbage is long and plentiful there tends to be a comparatively small larval-content in a rumen full of grass, but where herbage is scarce, as during times of drought, and on many farms during ordinary weather towards the end of the summer, a high concentration of larvæ is likely to be contained.

The kind of herbage has an interesting influence upon the accessibility of larvæ to the grazing animal, larvæ being able to climb more easily on to some kinds of herbage than on to others. The structure of a shoot of grass, for instance, is such that the greater part of the infective larvæ tend to remain near to the soil, being turned off the stem and along the under side of the

lower leaves. In clover, however, there is nothing to prevent a venturesome larva from climbing up the petiole and on to the trifoliate lamella of the leaf, and it is there that the great majority are actually found.

This factor is of particular significance where sheep are concerned. The highly selective grazing of these animals is now generally recognised, and it is probable that while picking the better part of the young growth of the grass plants they tend to leave the bulk of the worm larvæ behind on the coarse under-leaves; but while in clover, and selecting the green upper part of the leaf, they are taking the part which carries most of the worm larvæ.

It is suggested that this may be the mechanism which has led to the increased incidence of parasitic gastritis in Northumberland, following the extensive use of basic slag and the consequent increase of wild white clover in the pastures.

Patchiness of pasture and *time of day* also have an influence upon the rate of intake of infection.

(4) *The duration of a rest from grazing* by infected animals has an obvious influence upon the amount of infective material remaining in a pasture. Observations made at Weybridge have shown, however, that the natural death of the larvæ begins almost as soon as they have reached the infective stage, some of those which climb high into the grass being killed within a few hours by the drying action of sun and wind.

A more important consideration, however, is the effect of a rest upon the " number of larvæ per pound of herbage." This effect may be very great, particularly at a time of the year when the grass is making a rapid growth, and it is probably on account of the growth of grass as much as the death of the larvæ that benefit is derived through a rest from grazing.

Manuring with nitrates by forcing a rapid growth of grass to dilute the larvæ may produce a similar reduction in the number of larvæ per pound of herbage.

Of all the methods employed for the destruction of infective larvæ in a pasture, however, doubtless the best is the *eating off of the infective herbage by animals which are unsuitable for the development of the particular parasites concerned.* Larvæ which are picked up by the wrong host animal in this way are destroyed, and as an illustration of the effectiveness of the procedure, reference might be made to a certain paddock attached to a public thoroughbred stud which was found to carry some 6,000 " red-worm " larvæ per pound of herbage. Each of the several sheep placed there to clear up the infection would therefore collect and destroy some 90,000 larvæ daily, which might otherwise remain to infect the horses.

Haymaking is doubtless very effective for the removal of larvæ from an infected field.

Ploughing is probably not nearly so effective as is generally supposed, as the plough does not completely invert the soil surface and leaves a space between the furrows through which it is both easy and natural for the larvæ to migrate.

Harrowing can have little effect, and burning of the grass can only be carried out in particularly rough herbage where trouble from helminths is unlikely to arise.

Destruction of larvæ through the application of lime, salt, kainit, or other substances to the pasture has little or no effect.

Conclusions

To say that parasitic worms constitute the principal controlling factor in the achievement of maximum animal population through grassland farming is stating a truth that there can be no denying. On looking into sheep-farming practices—for it is the sheep-farmers who bear the brunt of the loss from parasitic worms—it is surprising to find how many of the age-old procedures of penning sheep, feeding them, and moving them, have their origin in the control of parasitic worms. This reason is, of course, generally unknown to the farmer, who has developed the methods through a long and costly period of trial and error. The oft-repeated adage that "sheep should never hear the church bells ring twice in the same field" doubtless refers to the period of six or seven days required for the development of the infective larvæ on the grass. The closed system of folding sheep over arable land with the movement of the pens every three days, and the farmers' belief that sheep which are being folded should never be allowed to "run back" on to land grazed some days previously, refer to the same factor. The removal of young sheep from rich crowded pasture on to clean land at the end of the summer refers to the accumulation of worm-infection on those pastures, as also does the restriction of the number of sheep to the acre, which is so forward a question in every sheep-farmer's mind, and sets a very definite limit to the profit that can be made out of an acre of sheep land.

It is no exaggeration to say that every good farmer knows almost to a sheep how many his land will carry, and if he exceeds that number in a normal year that they will cease to thrive and may even become diseased and die. It seems quite clear that the evil effects of overstocking and the parasitic disease that is brought on through keeping too many sheep is representative of some flaw in the adjustment of the parasites to the grazing animals, which may be described in popular terms as an upset of the "balance of Nature." Fortunately for the farmer, the powerful resistance to the development of parasites which the grazing animals ultimately acquire (provided that they do not die in the process) gives this balance a considerable amount of elasticity without which it would be impossible to crowd sheep together, even with the limited

success we now attain. The farmer, however, stretches the elasticity of this ecological balance to the very limit in order to make a profit out of his land, and trouble frequently results.

The number of sheep per acre is only *one* of the variable factors in the ecological unit of parasite, pasture, and grazing animal. With one or two rare exceptions a variation in the virulence of the parasitic worms (apart from differences which are peculiar to the various species) is not known to occur, but a lowering of the resistance of the grazing animal as may be brought about through deficient food, or resulting from the increased susceptibility of a group of animals containing too many immature individuals, are common causes of increased worm-burden. This same result can just as easily be brought about by the derangement of a wise rotation of grazing, or the shortage of pasture and the poverty of its nutritive qualities that often occur towards the end of the summer. What may justly be regarded as reasonable stocking during an ordinary year may constitute overcrowding during a drought. Indeed, the variable factors are very numerous, and there are many small alterations, unknown to the farmer's rule of thumb, which favour an increase of the parasites beyond the broad limits of the natural balance, and disease results.

The loss to the country from these parasites is very great indeed, both from outbreaks of obvious disease and from bad thriving. Figures are difficult to obtain, but I am aware of one farmer who lost between £4,000 and £5,000 as a result of parasitic gastritis during the course of five years' arable sheep-farming, and of 43 sheep-farmers in Kent who, on inquiry, were clearly shown to have lost over £10,000 between them during an epidemic of the disease in the drought of 1933-4.

So long as the farmer stocks his land to the maximum and remains ignorant of the factors which influence the increase of parasitic worms, these losses will continue. Eradication of the parasites is quite out of the question at the present time, so that we must do what we can to control their increase. Recent observations on the factors which lead to this end are distinctly helpful, but the struggle to keep the numbers of parasites down is likely to be a long one, and the danger of worm disease will dog the progress of greater stock production through grassland improvement until practical methods of eradicating the parasites have ultimately been found.

XUM

News

SIR FREDERICK HOBDAY'S WILL

As reported in the Press, Sir Frederick Hobday, who died on June 24, left estate of the gross value of £11,676, with net personalty £11,072. He left his professional and surgical instruments to the students' libraries and surgical departments of the various veterinary training colleges in Great Britain and Northern Ireland, the Royal Veterinary College in Camden Town to have the first selection; £100 to the Royal College of Veterinary Surgeons, to pay as a students' prize—open to all veterinary training colleges in Great Britain and Northern Ireland—the travelling fare of a third-year student to visit either a French, German, Dutch, Danish, or Italian veterinary school.

CONFERENCE AT THE WAR OFFICE

A CONFERENCE was held at the War Office on September 11, 1939, at which were present:—

The Director, Army Veterinary Services, with his Assistant Officers.

The President of the Royal College of Veterinary Surgeons—Professor G. H. Wooldridge, F.R.C.V.S., M.R.I.A.

The President of the National Veterinary Medical Association—H. W. Steele-Bodger, Esq., M.R.C.V.S.

E. C. Lloyd, Esq., M.R.C.V.S., Deputy Chief Veterinary Officer, Ministry of Agriculture.

The Secretary of the Royal College of Veterinary Surgeons—Dr. Fred Bullock, LL.D.

The conference discussed the requirements of the Royal Army Veterinary Corps in this war and the position of Panel "A" and "B" Veterinary Officials under the Agriculture Act, 1938, in relation to Military Service.

The liability of Veterinary Students to Military Service was discussed.

The Conference decided to represent to the War Office and Ministry of Labour certain matters the outcome of which we hope to disclose at an early date.

Members of the profession who are at present without any definite liability for Military Service will serve the national interest best by remaining in their appointments or practice until a further statement is published.